



Do people really want renewable energy? Who wants renewable energy?: Discrete choice model of reference-dependent preference in South Korea

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ABSTRACT

Renewable energy is gaining more attention than before in terms of tackling climate change and ensuring the public safety. The South Korean (hereafter, Korean) government has announced various policies to expand renewable energy sources and reduce the share of nuclear and coal-fired power. Since the energy sources are directly related to the lives of people, it is important to identify the public's acceptability of changes in the energy mix. Therefore, the purpose of this study is to analyze public preferences for changes in the shares of energy sources. For estimation of preference, this study used a mixed logit model that reflects the reference point to consider the relative shares of the energy sources and the relative level of attributes. In addition, this study used a hierarchical Bayesian logit model to examine whether the public characteristics result in any preference difference on the electricity service attributes. The results show that the Korean public's acceptability is high for renewable energy source expansion policy. Based on the analysis, this study found that the respondent's level of education had a significant effect on the preference for increase of renewable energy sources.

1. Introduction

After the adoption of the Kyoto Protocol (1997), which was mainly led by developed countries, the Paris Agreement (2015) was adopted, and interest in tackling climate change subsequently expanded globally. In particular, since the adoption of the Kyoto Protocol, developed countries have focused on transitioning to a low-carbon energy mix by expanding the shares of nuclear and renewable energy source as a policy goal.

Although the government's primary role is to set specific targets for the total power generation and each energy source, they must consider the uncertainty in the energy demand. As a result, the main energy policy is often one that deals with setting the shares of different energy sources within the overall power generation. As shown in Table 1, power generation is comprised of various energy sources, and naturally, the sum is set to 100%. In this setting, increasing the share of one particular energy source is only possible when the shares of other energy sources decrease. Thus, switching to a low-carbon energy mix requires a reduction in the share of coal-fired power plants, which naturally requires an increase in the share of other energy sources, such as nuclear and renewable energy power.

However, since the 2011 Fukushima Daiichi nuclear disaster, the public's reliability in nuclear energy has relatively decreased, while the interest in renewable energy has increased drastically (Chen et al., 2014). In June 2017 in South Korea, which previously aimed to expand the share of nuclear energy by 2040,¹ there had been many disputes about changing the direction of the energy policies (Energy Information Administration, 2016). President Moon's administration, inaugurated in 2017, has been pushing for the public debate about the installation of two new nuclear power plants that are now under construction. In addition, the Korean government has temporarily suspended the operation of eight aged coal-fired power plants for a month in June 2017.²

In the case of renewable energy sources, the Korean government previously aimed to expand the share of renewable energy source to 11% by 2020 (Ren, 2015).³ However, the new administration announced the *Renewable 3020*, which plans to increase the share of renewable energy by up to 20% by 2030. The plan also states that it will reduce the generation share of both nuclear and coal-fired power generation by 20–23.9% and 36.1%, respectively. The energy mix target proposed by the plan is described in Table 1.

Although the cost of renewable energy source is declining (International Energy Agency, 2016), it is still considerably higher than

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¹ South Korea was the only country to increase the share of nuclear power among OECD (Organization for Economic Co-operation and Development) member states.

² South Korea is a country where carbon emissions are rising at the fastest pace among other OECD member states (International Energy Administration, 2016). OECD countries' per capita carbon emissions decreased by 7.2% from 10.29 t in 1990 to 9.55 t in 2013, while South Korea's skyrocketed by 110.8% from 5.41 t to 11.39 t during the same period.

³ As of 2016, the share of renewable energy source in South Korea is 4.9%. As of 2017, the share of renewable energy sources has increased to 6.2%.

Table 1
3020 plan's target share of energy source (Ministry of Trade, Industry and Energy, 2017).

Year	Nuclear energy	Coal-fired power	LNG	Renewable energy	Oil	Hydro power	Total
2017	30.3%	45.4%	16.9%	6.2%	0.6%	0.7%	100%
2030	23.9%	36.1%	18.8%	20.0%	0.3%	0.8%	100%

the cost of nuclear and coal-fired power generation (Energy Information Administration, 2017). In addition, the cost from expanding the share of renewable energy source, which may be imposed on the public, will further increase. In Japan, where renewable energy source is expanding fastest in Asia (International Energy Agency, 2016), people are currently paying additional 792 yen per month as renewable energy dues since 2017 (Ministry of Economy, Trade and Industry, 2017).⁴ As the Japanese directly witnessed the Fukushima Daiichi nuclear disaster, their resistance to a tax hike is relatively low. Hence, it was less challenging for the Japanese government to finance renewable energy, which allowed Japan to successfully expand solar photovoltaic (PV) and wind energy (Ministry of Economy, Trade and Industry, 2012).

In Europe, individuals are highly likely to accept the government's nuclear plant shutdown (or reduction of its share) and less likely to reject an electricity bill hike caused by the expansion of renewable energy source. In this context, the German government banned the construction of any new nuclear power plant after the 2011 Fukushima Daiichi nuclear disaster. Unlike Germany, there is a considerable resistance from the Koreans to an increase in electricity bill, including taxes (Kim and Kim, 2015). Accordingly, it is essential to gain the public's consent on an energy cost hike related to renewable energy source expansion for the government to successfully achieve the *Renewable 3020* plan.

Due to the Korean constitution limiting the referendum to a matter regarding national defense, diplomacy, and reunification, there has never been a referendum regarding an energy policy. As a result, a questionnaire survey has been conducted to identify the public's preferences on the changes in the shares of energy sources. The discrete choice experiment which is survey instrument was also utilized to predict the public's acceptance of the expansion of renewable energy's share and how much they are willing to pay for such a change (Train, 2009). The discrete choice model is used to analyze the data from the discrete choice experiment. Majority of the previous studies that analyzed the public preferences on electricity service and renewable energy source using the discrete choice model incorporated the share of an energy source by reflecting them in the attribute level directly in the model (as an absolute number).

However, the public does not evaluate the alternatives by considering the absolute level of attributes constituting hypothetical alternatives. Rather, they evaluate the alternatives by considering the relative difference between the current state as a reference point and the attribute level of an alternative (Tversky and Kahneman, 1991). In this regard, behavioral economics and psychographic analysis studies revealed that the relative attribute level reliant on a reference point, not the absolute attribute level of a product or service, played an essential role in determining the respondent's preferences (Dellavigna, 2009; Carson and Groves, 2007; Hardie et al., 1993; Tversky and Kahneman, 1991). Furthermore, considering consumer behavior analysis, one of the studies argues that a model reflecting a reference-dependent function is better than the standard economic model (Bateman et al., 2009).

In addition to the importance of reference-dependent preferences, changes in the share of an energy source itself are relative and affected by the share of another energy source. Nevertheless, there is almost no study that incorporates a reference point in the discrete choice model

and analyzes the public preferences for changes in the shares of energy sources. Therefore, the purpose of this study is to consider a reference point to analyze the public's preferences for relative changes in shares of energy sources using the discrete choice model based on reference-dependent preferences.

In this process, previous studies that simply consider the difference between the attribute level and the reference point in the discrete choice model can only be applied to attributes with the same preference direction. However, for attributes with a different preference direction, such as renewable energy sources, it is necessary to draw out the individual parameter of each respondent. Therefore, this study used a general mixed logit model in the first step to derive the individual heterogeneity among discrete choice models. In the second step, this study analyzed the preferences by preference direction and non-preference direction for renewable energy source using mixed logit model considering reference-dependent preferences. Additionally, this study used the hierarchical Bayesian (HB) logit model to more specifically identify whether respondents' characteristics resulted in any preference differences on the level of electricity service attributes, including the type of energy source.

The summary and results of the analysis process of the Korean consumer's preference for electricity services using various econometric models are as follows. This study found that under the current energy mix, consumers preferred to increase the share of renewable energy sources. However, the 30.7% of respondents did not prefer to increase the share of renewable energy sources. The marginal utility of respondents who preferred the expansion of renewable energy sources was 4.164, while it was − 8.070 for respondents who did not prefer the expansion of renewable energy sources. Considering the number of respondents and the marginal utility of each group, this study found that Korean consumer's acceptance towards the expansion of renewable energy sources was high. Finally, this study also found that respondents who prefer the expansion of renewable energy and had higher education level were more sensitive to the expansion of renewable energy sources. On the other hand, among the respondents who did not prefer the expansion of renewable energy sources, those with higher satisfaction with the current electricity services were more sensitive to the expansion of renewable energy sources.

This study consists of the following sections. Section 2 examines the studies on government policy on the energy mix and those that analyzed the public preferences for electricity service. Section 3 introduces the general methodology on discrete choice experiment and model performed for this study. Section 4 presents the survey instrument and model specifications. Section 5 discuss the results estimated by the model. Finally, Section 6 examines this study's conclusions and implications.

2. Literature review

Many previous studies have acknowledged the government's policy as a significant factor in promoting national energy sources and determining the energy mix. Cases of employing different political instruments to change the diffusion and the growth rate of energy sources may be found in the literatures on energy system transformation (Barquin, 2014; Colli et al., 2014; Ratinen and Lund, 2014; Ciarreta, 2011). These studies analyzed the government's role in designing a new energy mix, developing energy sources, and promoting the growth of utilities. Koster and Anderies (2013) propose that a successful transition

⁴ The renewable energy dues paid by Japanese are increasing annually from about 474 yen/month in 2015 to about 675 yen/month in 2016.

in the energy system, such as changing the energy system or increasing the renewable energy source, can only be achieved by technological developments and optimal energy policies that satisfy the social factors.

The study by Peidong et al. (2009) examined the potential role of the Chinese government in promoting various renewable energy sources. In addition to emphasizing the government's role as a promoter of the renewable energy industry, the authors also identified that ensuring the correlations between different policies and the public's acceptance was essential in the growth of the renewable energy industry. In addition, Wustenhagen et al. (2007) evaluated the studies that analyzed social acceptance for renewable energy technology. The authors identified that the public's awareness towards renewable energy had a significant effect on the public's preference and the acceptance of energy sources.

Some studies have also found that the public's acceptance and trust in the government have a significant impact on the success of energy policies (Bronfman et al., 2012; Morell and Magorian, 2011). Cavallaro and Ciraolo (2005) identified that public acceptance was a significant factor that affected the success of new energy sources. The authors derived the most optimized type of wind power plant by considering the public's acceptance, surrounding geography, and energy situation of the residents. The results showed that the residents preferred to install a wind power plant far away from the island's tourist attraction, even though it costs marginally more. These findings contrasted with the general government policies that mainly pursued lower electricity costs and revealed that precise analysis of the public's preference and acceptance was necessary.

Evaluation of the public's acceptance of government policy and renewable energy has been discussed in many previous studies (Murakami et al., 2015; Kaenzig et al., 2013; Kosenius and Ollikainen, 2013; Cicia et al., 2012; Gracia et al., 2012; Komarek et al., 2011; Borchers et al., 2007). Table 2 briefly describes some of the studies related to the topic. These studies utilized various econometric models and the survey data of the respondents to analyze the public's preferences in and acceptance of different electricity services. By comparing the respondents' preferences in the different electricity services, these studies identified that the public preferred renewable energy over the traditional energy sources, which are fossil fuels and nuclear energy.

There have been some studies that analyzed the public's preference and acceptance of electricity services in South Korea. Jang (2014) utilized the discrete choice experiment and hierarchical Bayesian nested logit model to estimate the socially acceptable cost of locations of utility facilities. Based on the public's preferences for energy sources (coal, gas, nuclear energy, wind power, solar power, and biomass), the author estimated the marginal willingness-to-pay (MWTP) to social acceptance cost of installing different power plants. The results showed that the social acceptance cost for nuclear energy was the highest, meaning the

government had to pay the most to increase the public acceptance, while the cost for renewable energies was relatively low. Huh et al. (2015) utilized the mixed logit model to analyze the public preferences and acceptance of different electricity services and found that people mostly preferred the renewable energies.

The aforementioned studies analyzed the public preferences and acceptance of energy sources and how the government policies affected them, and they utilized econometric methods that made direct estimations. While these studies are effective in identifying the potential preferences of the public and suggesting policy implications based on such analyses, they provide limited insights on the group that does not prefer the expansion of renewable energy sources. This could result in a stated preference bias when hypothetical preferences in the discrete choice experiment are over- or under-interpreted compared to the actual preferences. To overcome these limitations, an asymmetrical approach model that incorporates the reference-dependent preference can be utilized. According to the studies that utilize a similar methodology to this study, for a change in the same attribute, different marginal utility values are derived when the respondents are divided into a preferred and non-preferred group. Comparing the absolute value of the marginal utility, it is generally known that marginal utility value of the non-preferential direction is larger than the preference direction.

Therefore, this study proposes the answer to the following research questions. First, is the number of respondents in favor of renewable energy sources overwhelmingly large enough to sustain the expansion of renewable energy sources? Second, if there is a significant number of respondents who do not prefer the expansion of renewable energy sources, what is their degree of non-preference to the degree of preference of the group that prefers the expansion of renewable energy sources? Third, considering the number of respondents and the marginal utility of both preference and non-preference groups for renewable energy sources, will the policy of expanding the proportion of renewable energy sources still be justified? Fourth, what characteristics of the respondents in each group influence their preferences towards the expansion of renewable energy sources? To answer these questions, this study thoroughly analyzes the consumer preference towards renewable energy sources by utilizing both mixed logit model and HB logit model that incorporates the reference-dependent preference.

3. Methodology

3.1. Discrete choice experiment

This study used the discrete choice experiment often called conjoint analysis and collected data to analyze the public's acceptance of electricity service, including the type of energy source. The discrete choice experiment with the stated preference approach provides hypothetical alternatives constructed with different levels of the objective's

Table 2
Studies that analyze public preference for energy sources.

Subject	Author	Country	Model	Energy source	Most preferred
Energy sources	Komarek et al. (2011)	U.S	Probit model	Natural gas, wind power, solar power, biomass	Wind power
	Cicia et al. (2012)	Italy	Latent class model	Wind power, solar power, biomass, nuclear energy	Wind and solar power ^a
	Kaenzig et al. (2013)	Germany	Mixed logit model	Fossil fuels, nuclear energy, renewables	Renewables
	Jang (2014)	Korea	Hierarchical Bayesian nested logit model	Fossil fuels, nuclear energy, Wind power, solar power, biomass	Solar power
	Huh et al. (2015)	Korea	Mixed logit model	Fossil fuels, nuclear energy, renewables	Renewables
Renewable energy sources	Murakami et al. (2015)	U.S., Japan	Mixed logit model	Nuclear energy, renewables	Renewables
	Borchers et al. (2007)	U.S.	Nested logit model	Wind power, solar power, biomass	Solar power
	Gracia et al. (2012)	Spain	Mixed logit model	Wind power, solar power, biomass	Solar power
	Kosenius and Ollikainen (2013)	Finland	Nested logit model	Wind power, wood	Wind power

^a The latent class model found that Class 1 preferred wind power, while Classes 2 and 3 preferred solar power.

attributes to the respondents, who then choose the best alternative that maximizes their utility (Haaizer and Wedel, 2003). The discrete choice experiment presents hypothetical products not available in the market or policies as alternatives and is used across various fields as an approach to represent a situation similar to the process where the respondent actually selects an alternative (Thyne et al., 2006; Green and Srinivasan, 1978). Here, the total number of attributes making up the alternatives should not be more than eight (Phelps and Shandteau, 1978).

The discrete choice experiment has the advantage of overcoming the multicollinearity problem encountered in common regression analysis of observational studies (Thyne et al., 2006; Haider and Ewing, 1990) because an orthogonal fractional factorial design to set the discrete choice experiment has no correlation among the attributes (Danaher, 1997). In addition to that, discrete choice experiments allow researchers to combine a number of attributes related to service and to control the alternative sets (Thyne et al., 2006; Haider and Ewing, 1990).

While the type of energy source in the future is expected to change differently from that in the present, there is a probability that the number and duration of blackouts would increase as a result of the expansion of intermittent renewable energy sources. In this situation, only using the currently available data has limitations to identify the public's awareness. Accordingly, the discrete choice experiment, which presents the respondents with alternative sets consisting of electricity service attributes in a similar setting where they select their alternative, is considered as an appropriate approach to analyze the public preferences and acceptance of electricity service.

3.2. Mixed logit model considering reference-dependent preferences

The present study used the discrete choice model to analyze data collected from the aforementioned discrete choice experiment. More importantly, this study applies the mixed logit model, which can incorporate heterogeneity in preferences for each respondent, meaning that it can identify an individual respondent's preference for every attribute. The mixed logit model is based on the theory of random utility. In the random utility model, which is expressed as Eq. (1), (U_{nj}) represents the utility respondent n gains from their selected alternative j (Train, 2009; McFadden, 1973).

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \beta'_{nk} X_k + \varepsilon_{nj}, \quad \beta_{nk} \sim N(b, W) \quad (1)$$

In Eq. (1), a respondent n 's utility (U_{nj}) can be divided into a deterministic term (V_{nj}) and a stochastic term (ε_{nj}) that denotes uncertainty. The deterministic term can be expressed as the multiplication of the vector (X_k) , which refers to the attribute of the alternative (j) affecting respondents' utility, and the coefficient vector (β_{nk}) , a value assigned to each attribute of the alternative. In short, the deterministic term refers to explainable attributes of the product. In contrast, the stochastic term refers to unexplainable and unobservable attributes of the product, such as the respondent's personal traits. The form of a discrete choice model varies depending on the assumption of how the stochastic term is distributed. This study assumed that the deterministic term was $\beta_{nk} \sim N(b, W)$, and the stochastic term followed the i.i.d. (independent and identically distributed) type I extreme value distribution.

The shares of energy sources, an attribute incorporated in the discrete choice experiment, have the current share of each type of energy source as a reference point (Hess et al., 2012). In the reference-dependent utility, the value function (v) is not defined by the absolute level of an alternative attribute, but by its difference with the reference point (r) (Dellavigna, 2009; Kahneman and Tversky, 1979). Depending on the inequality sign that captures the reference-dependent preferences, the difference in the attribute level and the reference point can be expressed as Eq. (2).

$$v(x|r) = \begin{cases} x - r & \text{if } x \geq r \\ \lambda(x - r) & \text{if } x < r \end{cases} \quad (2)$$

In the reference-dependent preferences, non-preference direction coefficients are bigger than their preference direction counterparts. As a result, the loss aversion parameter (λ) , which divides the non-preference direction coefficient by the preference direction, is observed as greater than 1. Under this condition, the estimation results of the standard discrete choice model (general mixed logit model) that shows the marginal utility (coefficient) for renewable energy source as being positive should not be taken straightforwardly to avoid any bias. For example, if there is a significant number of respondents who do not prefer renewable energy sources, the policy to unconditionally expand the renewable energy may not be very appropriate.

Considering this reason, respondents first need to be divided based on their different preferences on renewable energy source into preference and non-preference to examine the loss aversion parameter. To do so, this study first applied the general mixed logit model (Eq. (1)) to identify individual respondents' preferences in renewable energy source. Then, as the second step, this study applied the mixed logit model considering reference-dependent preferences (advanced mixed logit model) that divided the preferences into preference direction and non-preference direction (Kim et al., 2016). The advanced mixed logit model is specified in Eq. (3) as follows:

$$U_{nj}^2 = I(\text{re is renewable energy}) \{ I(\beta_{n,re}^1 \geq 0 \& x_{re} \geq r_{re} \text{ or } \beta_{n,re}^1 < 0 \& x_{re} < r_{re}) \beta_{n,re}^2 |x_{re} - r_{re}| + I(\beta_{n,re}^1 < 0 \& x_{re} \geq r_{re} \text{ or } \beta_{n,re}^1 \geq 0 \& x_{re} < r_{re}) \beta_{n,re}^2 \lambda |x_{re} - r_{re}| \} + \sum \beta_{n,k}^2 x_k + \varepsilon_{nj} \quad (3)$$

3.3. Hierarchical Bayesian logit model considering reference-dependent preferences

After identifying the respondents' preferences, this study utilized the HB model to elaborately analyze how preferences for electricity service attributes vary depending on the respondent's characteristics. The HB model defines the coefficient vector (β_{nk}) individually for each respondent to represent the respondent's preferences for each attribute. Each respondent's utility is denoted similarly to Eq. (1), and the individual's coefficients reflect the differences between the respondents (Allenby and Rossi, 1998). More specifically, the model is expressed as Eq. (4) as follows:

$$\beta_{nk} = \Gamma z_n + \zeta_n \quad \zeta_n \sim N(0, \Sigma) \quad (4)$$

In Eq. (4) described above, z_n is the vector that denotes the characteristics of the respondent (n) , Γ is the matrix for the coefficient (z_n) , ζ_n is the stochastic term for unobserved differences of the respondent, and Σ is the covariance between the partial values (Allenby and Ginter, 1995).

Generally, the Bayesian analysis estimates each parameter's posterior distribution by combining likelihood, which is determined by the data based on the prior distribution of each parameter. Eq. (4) plays a role of identifying the prior distribution for β_{nk} , and the prior distributions of Γ and Σ should be established to complete the HB model. Accordingly, this study established Eq. (5), in which Γ follows the normal distribution and Σ follows the inverse-Wishart distribution.

$$\begin{aligned} \Gamma &\sim N(a, A) \\ \Sigma &\sim W(w, W) \end{aligned} \quad (5)$$

The present study applied the Markov chain Monte Carlo (MCMC) simulation, which is commonly used in Bayesian econometrics (Train, 2009). The MCMC conditionally considers parameters, repeats the extraction of probabilities, and identifies the distribution that converges toward each parameter's posterior distribution. This study also utilized the Gibbs sampling, one of the most widely used extraction methods. In

hierarchical Bayesian estimation, the MCMC is processed through three steps as shown in Eq. (6):

$$\begin{aligned} & \Gamma | \Sigma, \beta_{nk} \\ & \Sigma | \beta_{nk}, \Gamma \\ & \beta_{nk} | \Gamma, \Sigma \end{aligned} \quad (6)$$

When the covariance between the partial values (Σ) and the individual partial value of an attribute (β_{nk}) were given, this study extracted the coefficient (Γ) for the variable of an individual's characteristics (z_n). In addition, this study extracted Σ when β_{nk} and Γ were given, and β_{nk} when Γ and Σ were given. With the probability extraction process described above, two parameters that reflect the parameters' hierarchical structure were considered conditionally (Allenby and Ginter, 1995).

In order to estimate the mentioned models, a traditional estimation method based on the maximum likelihood estimation (MLE) can be used to estimate the value for each attribute. Nonetheless, calculation of the MLE is complex, and there could be a challenge where the maximum likelihood value could vary depending on the initial value. To solve the calculation problem, this study used the Bayesian estimation method. The Bayesian estimation method uses the attribute coefficient, the prior distribution for marginal utility and the posterior distribution of the likelihood function, with strengths that it can obtain consistency and efficiency in a more flexible conditions than the MLE (Edwards and Allenby, 2003). Therefore, this study used Bayesian estimation method.

4. Survey and model specifications

4.1. Survey design and data description

The survey in this study was conducted with 400 people (aged from 20 to 59 years) in the main residential areas with the highest population in South Korea⁵ to represent the total population regarding their preferences in and awareness of the electricity service. The interviewees were selected using probability sampling with quotas. Specifically, the samples were assigned according to the population's characteristics such as gender, age, and proportions of the residential region. Probability sampling with quotas show no difference with probability sampling regarding the samples' representation and are more useful than probability sampling in terms of time and cost (Sudman et al., 1996). The survey was performed an individual interview survey through Gallup Korea, a market research firm (See Appendix C for respondents' characteristics).

The questionnaire utilized in this study consists of two parts. The first part examines the following questions regarding the respondent's perception and usage of electricity services: 1) the degree of interest in the electricity service, 2) the degree of satisfaction with the electricity services, 3) the importance of each factor in the electricity services (see Appendix A for further questions in the first part.) The second part conducts the discrete choice experiment to obtain the information about the public's preference on different electricity service alternatives under hypothetical circumstances.

The discrete choice experiment used in this study is the same as used in Huh et al. (2015)'s experiment data, which referenced previous studies on the public preferences of electricity service. Table 3 shows attributes and level of the attributes considered in the discrete choice experiment. The attributes of the electricity service were set up based on the current energy mix in Korea and the potential technological benefits and cost of implementing new services. The attribute level of “share of energy resources” represented the potential changes to the current energy mix. The attribute level of “smart meter” represented the

Table 3

Attributes and levels included in discrete choice experiment for the electricity service.

Attribute	Level
Share of energy sources	Maintaining the current shares of energy sources Significantly increasing the share of nuclear energy Significantly increasing the share of fossil fuels Significantly increasing the share of renewable energy
Smart meter	Not installed Installed
Number of blackouts (blackouts/year)	Once/year Twice/year Three times/year
Duration of each blackout (10 min/blackout)	10 min/blackout 30 min/blackout 60 min/blackout
Active social contribution	Passive social contribution Active social contribution
Additional electricity bill	Additional electricity cost of US\$ 1.0 Additional electricity cost of US\$ 3.0 Additional electricity cost of US\$ 5.0

decision to install or not install the smart meter. The attribute level of “number of blackouts” were based on how many unannounced blackouts occurred in one year. The attribute level of “duration of each blackout” represents the average duration of any type of blackout. The attribute level “active social contribution” represented the degree of social contribution the power companies were practicing.

Among the six attributes that comprise each alternative in the discrete choice experiment, “additional monthly electricity bill cost” is one of the most important attributes that affect the public's preference for electricity services. Electricity costs may differ for each energy source as mentioned in the introduction, and each country has different units of power generation cost depending on the shares of power sources. In particular, electricity costs tend to increase in large parts as the share of renewable energy source increases (Moon et al., 2011). Accordingly, it can be assumed that the additional level of increase in monthly electricity costs reflects the expected increase in the renewable energy share. In this regard, the results of studies by Kim et al. (2012) and Yoo and Kwak (2009), which analyzed the Korean public's preferences for renewable energy sources using the contingent valuation method (CVM), showed that the average additional monthly household MWTP for renewable energy was KRW 1563 to KRW 2072. Thus, taking into account the MWTP and inflation rates of the previous studies, Huh et al. (2015) set the level of ‘additional monthly electricity bill cost’ to KRW 1000, KRW 3000, KRW 5000. To help understand the magnitude of the value and the interpretation of data, this study converted this monetary value to a constant dollar term.⁶ Using these values, the monetary value of the survey attributes was converted as \$1.00, \$3.00, and \$5.00. All subsequent monetary units in this study are represented by the constant dollar term.

The number of possible combinations of alternatives with six electricity service attributes and the levels of each attribute in Table 3 is a total of 432 ($4 \times 2 \times 3 \times 3 \times 2 \times 3 = 432$). However, it is practically challenging to use all the 432 alternatives to analyze the public preferences. Thus, this experiment established 24 alternative cards using the orthogonal fractional factorial design mentioned above. These alternatives were divided in half to construct A and B type questionnaires, each utilizing 12 alternatives. Ultimately, four choice sets, each made up of three alternative cards, were adopted. Interviewers asked the respondents to choose the most preferred electricity service alternative

⁵ Seoul, Gyeonggi Province (new cities) and five metropolitan cities (Busan, Incheon, Daegu, Daejeon, and Gwangju) represent about 48% of the whole population in Korea (KOSIS, Korea Statistical Information Service).

⁶ Since the exchange rate, inflation rate and the purchasing power of the dollar are constantly changed, it was necessary to convert the monetary value of KRW (2014) to USD (2017) to make the correct interpretation. (West, 1983).

Table 4

An example of discrete choice experiment presented to respondents in this study.

	Type A	Type B	Type C
1. Share of energy sources	Significantly increasing the share of fossil fuels	Maintaining the current shares of energy sources	Significantly increasing the share of renewable energy
2. Smart meter	Installed	Not installed	Installed
3. Number of blackouts	Three times/year	Three times/year	Twice/year
4. Duration of each blackout	60 min/blackout	30 min/blackout	10 min/blackout
5. Active social contribution	Passive social contribution	Active social contribution	Passive social contribution
6. Additional monthly electricity bill	Additional monthly electricity cost of US \$ 1.0	Additional monthly electricity cost of US \$ 3.0	Additional monthly electricity cost of US\$ 3.0
Most preferred type (Choose one among 3)	Type A	Type B	Type C

of each alternative set. An example of the discrete choice experiment in this study is shown in Table 4 (See Appendix B for complete choice sets of both A and B type questionnaires).

4.2. Model specifications

The present study utilized the general mixed logit model to perform an analysis in the first step. Specifically, Eq. (7) is the modified version of Eq. (1), denoting the utility acquired by the respondent n by choosing alternative j . Eq. (7) denote how the survey data is reflected in the utility function.

$$\begin{aligned}
 U_{nj} = & \beta_{n,nuclear,inc}^1 d_{nuclear,inc} + \beta_{n,fossil,inc}^1 d_{fossil,inc} + \beta_{n,renewable,inc}^1 d_{renewable,inc} \\
 & + \beta_{n,smartmeter}^1 d_{smartmeter} + \beta_{n,blackout,num}^1 x_{blackout,num} \\
 & + \beta_{n,blackout,dur}^1 x_{blackout,dur} + \beta_{n,social\ contribution}^1 d_{social\ contribution} \\
 & + \beta_{n,electricity\ bill,inc}^1 x_{electricity\ bill,inc} + \varepsilon_{nj}^1
 \end{aligned} \quad (7)$$

Here, $d_{nuclear,inc}$, $d_{fossil,inc}$, $d_{renewable,inc}$ are the dummy variables that denote the proportion of nuclear, fossil fuel, and renewable energy sources. The baseline of these dummy variables are their proportions in the current energy mix. For example, if the “share of energy source” attribute level of alternative j is increased in the share of renewable energy source, $d_{renewable,inc}$ has the value of 1, while both $d_{nuclear,inc}$ and $d_{fossil,inc}$ has the value of 0. Next, $d_{smartmeter}$ and $d_{social\ contribution}$ are dummy variables indicating whether smart meter is installed or not, and whether the utility companies are actively contributing to the society. Similar to the aforementioned example, the variables have a value of 0 (smart meter not installed, passively contributing) and 1 (smart meter installed, actively contributing). $x_{blackout,num}$, $x_{blackout,dur}$, and $x_{electricity\ bill,inc}$ are linear variables that denote the number of blackouts, duration of each blackout, and additional monthly electricity bill. Thus, unlike the dummy variables, which are differentiated into value of 1 and 0, linear variables are reflected in the model by their numerical value corresponding to the property level of the specific alternative.

Under the assumption that each respondent chooses the alternative that maximize his utility, the probability that respondent n chooses alternative j with β_n condition is denoted by Eq. (8) (Train, 2009; McFadden, 1974). Here, j represents the specific alternative in the choice set chosen by the respondent, and i represents all the other non-chosen alternatives.

$$\begin{aligned}
 P_{nj}|\beta_n = & \Pr(U_{nj} > U_{ni}, \forall j \neq i) = \Pr(V_{nj} + \varepsilon_{nj} > V_{ni} + \varepsilon_{ni}, \forall j \neq i) \\
 = & \int_{\varepsilon} I(\varepsilon_{ni} < V_{nj} - V_{ni} + \varepsilon_{nj}, \forall j \neq i) f(\varepsilon_n) d\varepsilon_n = \frac{\exp(\beta_n' x_{nj})}{\sum_i \exp(\beta_n' x_{ni})}
 \end{aligned} \quad (8)$$

Although one can assume β_n follows various distribution other than normal in the mixed logit model, this study assumed that β_n follows a normal distribution in this study. The choice probability of respondent

n choosing alternative j is denoted by Eq. (9) (Train, 2009).

$$P_{nj} = \int \left(\frac{\exp(\beta_n' x_{nj})}{\sum_i \exp(\beta_n' x_{ni})} \right) f(\beta) d\beta \quad (9)$$

In Eq. (9), $f(\beta)$ is the probability distribution function, and the likelihood function can be expressed as the following Eq. (10).

$$L(y_n|\beta_n) = \prod_{n=1}^N \left[\exp(\beta_n' x_{nj}) / \sum_i \exp(\beta_n' x_{ni}) \right] \quad (10)$$

Next, in the case of Eq. (3), which denotes the advanced mixed logit model that analyzes the reference-dependent preference, the utility respondent n obtained by choosing alternative j is expressed by the following utility function in Eq. (11).

$$\begin{aligned}
 U_{nj} = & \beta_{n,nuclear,inc}^2 d_{nuclear,inc} + \beta_{n,fossil,inc}^2 d_{fossil,inc} + I(\beta_{n,renewable,inc}^1 \geq 0 \& d_{re} \\
 & \geq r_{re} \text{ or } \beta_{n,renewable,inc}^1 < 0 \& d_{re} < r_{re}) \beta_{n,renewable}^2 |d_{re} - r_{re}| \\
 & + I(\beta_{n,renewable,inc}^1 < 0 \& d_{re} \geq r_{re} \text{ or } \beta_{n,renewable,inc}^1 \geq 0 \& d_{re} < r_{re}) \beta_{n,renewable}^2 \lambda |d_{re} - r_{re}| \\
 & + \beta_{n,smartmeter}^2 d_{smartmeter} \\
 & + \beta_{n,blackout,num}^2 x_{blackout,num} + \beta_{n,blackout,dur}^2 x_{blackout,dur} \\
 & + \beta_{n,social\ contribution}^2 d_{social\ contribution} + \beta_{n,electricity\ bill,inc}^2 x_{electricity\ bill,inc} + \varepsilon_{nj}^2
 \end{aligned} \quad (11)$$

Comparing the utility function of Eqs. (7) and (11), there is a difference in how the dummy variable denoting the increase in the share of renewable energy sources, $d_{renewable,inc}$ (d_{re}), is reflected in the model. In the case that respondent n prefers the expansion of renewable energy sources (positive preference) in the first step of the analysis, and if the alternative denotes the expansion of the share of renewable energy sources, the respondent's preference follows the preference direction expressed by the second row of Eq. (11). If the alternative denotes the expansion of energy sources such as nuclear and fossil fuels (decrease in renewable energy sources), the respondent's preference follows the non-preference direction expressed by the third row of Eq. (11). In the case that respondent n does not prefer the expansion of renewable energy sources (negative preference) in the first step of the analysis, and if the alternative denotes the expansion of the share of renewable energy sources, the respondent's preference follows the non-preference direction expressed by the third row of Eq. (11). If the alternative denotes the expansion of energy sources such as nuclear and fossil fuel (decrease in renewable energy sources), the respondent's preference follows the preference direction expressed by the second row of Eq. (11).

Finally, as shown in Eq. (4), respondent's social psychological and demographic characteristics may be reflected in the HB model to define the coefficients for different attributes. The sensitivity (Γ) of these characteristics are derived to explain how they affect the respondent's preference of each attributes. The psychographic variables of electricity service satisfaction, electricity bill importance, and social issue interest

in Appendix C were reflected as z_n in the HB logit model. Additionally, among the respondents' demographic characteristics, level of education was included as a variable in z_n .

$$\begin{aligned}\beta_{n,nuclear,inc}^3 &= \alpha + \Gamma_{nuclear,inc,service,satisfaction} z_{n,service,satisfaction} \\ &\quad + \Gamma_{nuclear,inc,bill,importance} z_{n,bill,importance} \\ &\quad + \Gamma_{nuclear,inc,issue,interest} z_{n,issue,interest} \\ &\quad + \Gamma_{nuclear,inc,education,level} z_{n,education,level} + \zeta_n \\ \beta_{n,electricity,bill}^3 &= \alpha + \Gamma_{electricity,bill,service,satisfaction} z_{n,service,satisfaction} \\ &\quad + \Gamma_{electricity,bill,bill,importance} z_{n,bill,importance} \\ &\quad + \Gamma_{electricity,bill,issue,interest} z_{n,issue,interest} \\ &\quad + \Gamma_{electricity,bill,education,level} z_{n,education,level} + \zeta_n\end{aligned}\quad (12)$$

Here, it was challenging to identify electricity service satisfaction as electricity services comprise of various items that need to be considered. Thus, this study used the four questions to measure the satisfaction (See Appendix A). The respondent's level of education was added to the variables affecting the preference towards electric power service by the following reason. According to the existing studies, a significant positive correlation was found between the level of education and WTP for renewable energy source (Koundouri et al., 2009; Zarnikau, 2003), and that a person with a higher level of education was more likely to be sensitive to greenhouse gas emissions (Byun and Lee, 2017).

5. Results and discussions

5.1. Estimation results of the mixed logit model

The present study utilized the general mixed logit model to perform an analysis in the first step, and the estimation results are provided in Table 5. The results show that as the share of nuclear and coal-fired power, which had environmental risk, increases, the preference weakens. Thus, the public did not prefer to expand the shares of nuclear energy and fossil fuel energy with respect to the total shares of the energy sources, while they preferred to expand the share of renewable energy source. Such results indicated that consumers valued the preservation of the environment and were aware of the potential air pollution and risks related to the different energy sources.

As expected, the marginal utilities of the number of blackouts, duration of each blackout, and additional electricity bill were found to be negative (-). The coefficients of these attributes implied that the public preferred less chance of blackouts, shorter blackouts, and cheaper electricity bills. Meanwhile, the positive sign of the marginal utilities of the installation of a smart meter and the utility company's active social contribution were positive (+). The positive sign of these

Table 6

Degree of preferences for energy sources from the general mixed logit model.

Energy source	Preference (%)	Non-preference (%)
Nuclear energy	57 (14.3)	343 (85.8)
Fossil fuels	13 (3.3)	387 (96.8)
Renewable energy	277 (69.3)	123 (30.8)

attributes not only implied that the public preferred the utility companies to adopt new technologies such as the smart meter and actively participate in social contribution activities, but that consumers were willing to accept new technologies. The positive coefficient for the utility company's active social contribution may also indicate that the consumers were aware of the potential damages that utility companies were causing, and that they preferred these companies to provide some compensation.

Focusing on the type of energy source, this study calculated the percentages of respondents who preferred each type of energy source, and the results are described in Table 6. As demonstrated in Table 6, the percentage of respondents who did not prefer nuclear energy and fossil fuel energy was high, showing 85.8% and 96.8%, respectively. Considering renewable energy sources, the percentage of those who preferred these (69.3%) was more than double those who did not prefer them (30.7%).

Based on the estimated preference for renewable energy, this study checked and compared the demographic differences between the preference and non-preference group for renewable energy source as shown in Table 7. The estimation of age and household income were not statistically significant, which meant that respondents' income and age did not affect their degree of preference towards the renewable energy source. However, the number of female respondents who did not prefer the renewable energy source was higher than the number of female respondents who did prefer the renewable energy source.

In addition, the number of respondents who did not prefer renewable energy sources was rather significant, considering that the loss aversion parameter was larger than 1. If the loss aversion parameter, as explained above, is greater than 1, the people who did not prefer the expansion of renewable energy were statistically significant, meaning that it is not appropriate to pursue the policy of expanding renewable energy unconditionally. To analyze the degree of direction between the respondents, this study divided the preferences toward renewable energy source into preference direction and non-preference direction.

The result of the analysis of different directions (advanced mixed logit model) is presented in Table 5. The results show that, like the general findings of the previous studies (Kim et al., 2016; Masiero and Hensher, 2010; Hess et al., 2008; Tversky and Kahneman, 1991), the loss aversion parameter is 1.938, which is greater than 1. Such high loss aversion parameter may indicate that people with non-preference

Table 5

Estimation results of the respondents' marginal utility on electricity service attributes using the mixed logit model.

Attribute	General mixed logit model Coef. (Std. D)	Advanced mixed logit model Coef. (Std. D)
Increasing the share of nuclear energy	- 2.050*** (2.743 ***)	- 3.023*** (3.887***)
Increasing the share of fossil fuels	- 1.627*** (2.889**)	- 1.892*** (2.320***)
Increasing the share of renewable energy	1.201*** (3.192***)	
Preference for renewable energy		4.164 *** (1.356**)
Non-preference for renewable energy		- 8.070*** (2.579**)
Installation of a smart meter	0.331** (1.234***)	0.610*** (1.760***)
Number of blackouts (blackouts/year)	- 0.631*** (1.124 ***)	- 0.573** (1.623***)
Duration of each blackout (10 min/blackout)	- 0.192*** (0.694 ***)	- 0.270*** (0.908***)
Active social contribution	0.784* ** (1.560***)	0.964*** (1.866***)
Additional electricity bill (1\$/month)	- 1.207*** (1.117 ***)	- 1.513*** (1.423 ***)

***, **, and * refer to the significance at the 1%, 5%, and 10% levels, respectively.

Table 7
The difference of demographic for renewable energy preference and non-preference.

Demographic	Renewable energy		t-test	p
	Preference (n = 277) M ± SD	Non-preference (n = 123) M ± SD		
Gender (Male = 1, Female = 2)	1.195 ± 0.397	1.276 ± 0.449	1.818	0.070
Age (Year)	37.928 ± 9.705	36.276 ± 9.257	1.593	0.112
Household income (Average monthly)	40.029 ± 13.322	38.439 ± 11.502	1.147	0.252

direction have stronger intention to oppose the expansion of renewable energy source than the support intention the people with preference direction have. More specifically, the loss aversion parameter indicates that the people who did not prefer the expansion of renewable energy had about twice as much belief in their preference than the people who preferred the expansion of renewable energy. Thus, if renewable energy is expanded without the consideration of this loss aversion parameter, the consumer acceptance may not rise as quickly as the general mix logit result indicates.

However, the overall ratio of preferred respondents is 2.252 times larger than that of the non-preferred respondents. The ratio indicates that Korean respondents on average prefer renewable energy regardless of the principle of majority or utility rule, which is the process of rationalizing the decisions of individuals within the group. Ultimately, based on the mixed logit analysis results, this study interpreted that the Korean public's acceptance of government policy to expand the shares of renewable energy source is high.

5.2. Estimation results of the hierarchical Bayesian logit model

Further, this study used the HB logit model and performed an analysis to more specifically examine the differences in the public's preferences for electricity service attributes. Since the HB model directly relates the consumer's demographic and psychological characteristics to their part-worth, this included the “energy service satisfaction,” “electricity bill importance,” “social issue interest,” and “level of education” to better explain the consumer preference. Similar to the advanced mixed logit model used above, the model incorporated reference-dependent preferences for renewable energy source. The estimation results showed in Table 8 that the marginal utility of each attribute was similar to that of the general and advanced mixed logit models. Accordingly, while focusing on characteristics variables of respondents, this study found the following results.

This study begin by examining the results associated with the public's preference for increasing the share of renewable energy, which is the key theme of this study. As shown in Table 8, the characteristics that specifically affect the preference for increasing the share of

renewable energy are their “electricity service satisfaction” and “level of education”. First, if the respondents did not prefer a renewable energy source and were more satisfied with their current electricity service, they were more sensitive towards the increase of the share of renewable energy sources. In other words, if the respondent had a high level of satisfaction with the current electricity service, he or she was much more reluctant to accept policies that increase the shares of the renewable energy source. Such a finding indicates that consumers content with the status quo do not want any changes made to the energy mix. Next, if the respondents' level of education was higher and they preferred renewable energy source, they were more sensitive toward the expansion of renewable energy source. These results were consistent with the findings of the previous studies that proposed that the level of education had a significant effect on preferences and WTP for energy sources, including renewable energy source (Koundouri et al., 2009; Zarnikau, 2003).

As mentioned earlier, any changes in the share of renewable energy will affect the share of other energy sources like nuclear and coal-fired power generation. Accordingly, discussion about the public's preferences in the changes in the share of nuclear and coal-fired power generation should be included in the public's preferences in policies to expand renewable energy. As shown in Table 8, the characteristics of the respondents affecting the sensitivity of preference for increasing the share of nuclear power generation are “electricity bill importance,” “social issues interest,” and “level of education.” Here, “level of education” also affects the sensitivity of preference in the increase in the share of fossil fuels power generation. Thus, as the respondents' level of education got higher, they were more sensitive towards the expansion of nuclear energy and fossil fuel energy. In the case of the additional electricity bill characteristic, as the respondents' perceived importance of the electricity bill got higher, they were likely to prefer the increase in the share of nuclear energy. In other words, these respondents were shown to be less sensitive towards the expansion of nuclear energy. Such a finding may indicate that consumers who are sensitive to the increasing electricity bill understand how efficient and cheap the nuclear energy is compared to the other energy sources. Consumer's importance to electricity bill and energy source has been analyzed in

Table 8
Estimation results of the HB logit model.

Attribute	Means (β 's)	Respondent characteristics (α_d)			
		Electricity service satisfaction	Electricity bill importance	Social issue interest	Level of education
Increasing the share of nuclear energy	− 2.602***	0.268	0.567*	− 0.683***	− 0.847***
Increasing the share of fossil fuels	− 2.149***	0.013	− 0.119	0.212	− 0.698***
Increasing the share of renewable energy					
Preference for renewable energy	3.056***	0.002	0.224	− 0.120	0.388***
Non-preference for renewable energy	− 3.752***	− 0.920***	0.257	− 0.165	− 0.037
Installation of a smart meter	0.396***	− 0.062	− 0.132	0.232	− 0.057
Number of blackouts (blackouts/year)	− 0.527***	− 0.338	0.078	− 0.159	0.202
Duration of each blackout (10 min/blackout)	− 0.186***	− 0.199**	− 0.083	0.010	− 0.128
Active social contribution	0.835***	0.065	0.551**	− 0.320	0.037
Additional electricity bill (1\$/month)	− 1.489***	0.152	− 0.457***	0.191*	0.184

***, **, and * refer to the significance at the 1%, 5%, and 10% levels, respectively.

many past researches to show that consumers' attitude regarding environmental friendly energy source has a negative relationship with electricity bill amount. Some studies have indicated that as the electricity bill increased, consumers became less sensitive to the GHG emission or environmental damages (Hansala et al., 2008). Furthermore, in the case of social issue, the greater the social issue interest the respondents had, the more sensitive they were towards the expansion of nuclear energy. This finding could be evidence of the growing public opinions opposing the construction of new nuclear power plants. The social issues about the stability of nuclear energy have been growing since people witnessed the Fukushima Daiichi nuclear disaster, which gradually increased the fear of unstable energy source.

Finally, the interpretation of the analysis regarding the attributes other than the type of energy source are as follows. If the respondent's satisfaction towards the electricity service got higher, they were more sensitive to the duration of each blackout. In other words, once the respondents were content with the current electricity service, they felt a higher disturbance from longer blackouts than the average consumer. Simply put, based on these two attributes, consumers who were satisfied and preferred the present electricity service were more reluctant than the average consumer towards any changes that may disturb the energy supply. Furthermore, it was found that the greater social issue interest the respondents had, they were less sensitive towards the additional electricity bill. In other words, if the respondent was interested in the social issues related to the energy sources and government policies, they were very lenient toward the increase in the electricity bill than those who were not interested in social issues. Such a finding is consistent with the previous literatures that stated that people who are interested in social issues, such as the conservation of environment or the risk of nuclear accidents, are willing to pay more for a renewable energy source (Mozumder et al., 2011; Starr, 2009; Nomura and Akai, 2004). As expected, consumers who put more emphasis on "electricity bill importance" were shown to be more sensitive to the additional monthly electricity bill.

6. Conclusions and policy implications

The public naturally relies on the current shares of energy sources and then decide upon their preferences for government policy to change the shares of energy sources. More importantly, a government that is working towards expanding renewable energy source needs to monitor the public acceptance on renewable energy source closely and to pursue its policies, instead of expanding them unconditionally. In this regard, using the discrete choice model, which is widely used to analyze the public acceptance on policy, and incorporating the reference-dependent utility function in renewable energy source attribute, would make it possible to analyze the asymmetry in the public preferences on renewable energy source. The results identify significant implications for government policy expansion of renewable energy source. Existing studies that used the discrete choice experiment and discrete choice model to analyze the public acceptance of changes in the shares of energy sources incorporated absolute changes for the shares of energy sources in attribute levels. That is, there is almost no study that reflects the reference-dependent effect and analyzes the public acceptance of relative changes in the shares of energy sources. Therefore, this study first analyzed the public preferences for relative changes in the shares of renewable energy source, which considered the existing shares of energy sources. Then, based on the estimated preferences, this study captured the different preferences on the type of energy source and electricity service attributes depending on the public's demographic and psychographic characteristics to more accurately examine the public acceptance of the expansion of renewable energy source.

The estimation results of the general mixed logit model showed that the number of respondents who preferred renewable energy source was twice more than those who did not prefer such a source. The estimation results of the advanced mixed logit model, a mixed logit model

considering reference-dependent preferences, showed that the public's loss aversion parameter on renewable energy sources was more than 1 (1.938). However, the ratio of preferred respondents was 2.252 times larger than that of non-respondents, indicating that they prefer a renewable energy source regardless of the principle of majority or utility rule, which is the process of rationalizing the decisions of individuals within the group. Ultimately, based on the study's analysis results, Korean people's acceptance of government policy to expand the shares of renewable energy source could be interpreted as somewhat high.

Further, using the HB logit model, this study analyzed the public differences in the changes in the shares of renewable energy source depending on their characteristics. The results find that, for the respondents who preferred renewable energy source and higher the level of education they had, more sensitive to increase of the share of renewable energy source. In addition, for the respondents who did not prefer renewable energy source, higher the electricity service satisfaction they had, the more sensitive to the expansion of renewable energy source. Due to Korea's latest trends, the share of renewable energy source and that of nuclear energy have a high negative correlation. Thus, it requires an examination of the public awareness on expanding the share of nuclear energy. In this respect, it was found that greater the electricity bill importance the respondents had, the less sensitive to the expansion the share of nuclear energy; greater the social issue interest they had, the more sensitive to the expansion the share of nuclear energy.

In conclusion, to reduce the share of nuclear energy and increase the share of renewable energy sources, the government needs to pursue incremental electricity bill hikes while considering the public acceptance simultaneously. That is, the government must establish a long-term roadmap to decrease the share of fossil and nuclear energy while sustaining the acceptance rate of renewable energy sources by providing appropriate electricity costs throughout the process. In addition, the detailed analysis of respondents' preferences and characteristics showed that respondents' level of interest in social issues had a significant impact on their preference towards nuclear energy, which is related to renewable energy sources. Therefore, energy policymakers should promote multifaceted strategies that incorporate the heterogeneity of preferences to raise overall public interest in the energy industry. For instance, continually hosting the ongoing public debate on nuclear energy and advertising the pros and cons of renewable energy may allow the public to increase their awareness and acceptance of renewable energy. If these types of promotional campaigns are used as part of energy education for the public, including energy policy, it is expected to improve the public acceptance of government energy policy.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.enpol.2018.04.062>.

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